CLAIMS

We claim:

1. A catalyst system comprising: (1) at least one solid acid component and (2) at least one metal-based component, said metal-based component consisting essentially of (a) a metal combination selected from the group consisting of:

i) at least one metal from Group 3 and at least one metal from Groups 4-15 of the Periodic Table of the Elements;

ii) at least one metal from Groups 5-15 of the Periodic Table of the Elements, and at least one metal from at least one of Groups 1, 2, and 4 of the Periodic Table of the Elements;

iii) at least one metal from Groups 1-2, at least one metal from Group 3, and at least one metal from Groups 4-15 of the Periodic Table of the Elements; and

iv) two or more metals from Groups 4-15 of the Periodic Table of the Elements

and (b) at least one of oxygen and sulfur, wherein the at least one of oxygen and sulfur is chemically bound both within and between the metals.

2. The catalyst of system of claim 1 wherein the metal-based component is a combination of at least one of oxygen and sulfur, at least one metal selected from Group 3, and at least one metal selected from Groups 4-15 of the Periodic Table of the Elements.

3. The catalyst system of claim 2, wherein the at least one metal selected from Group 3 comprises at least one of scandium, yttrium, lanthanum, cerium, samarium, ytterbium and praseodymium; and the at least one metal selected from Groups 4-15 comprises at least one of titanium, zirconium, niobium, molybdenum, tungsten, manganese, iron,

cobalt, iridium, nickel, palladium, platinum, copper, zinc, aluminum gallium, indium, germanium, tin, antimony, and bismuth.

4. The catalyst system of claim 3, wherein the at least one metal selected from Group 3 comprises at least one of scandium, yttrium, lanthanum, and praseodymium and the at least one metal selected from Groups 4-15 comprises at least one of titanium, zirconium, manganese, iron, cobalt, nickel, copper, zinc, aluminum, indium, and tin.

5. The catalyst system of claim 2 wherein the at least one metal-based component comprises one or more of $Y_aIn_bZn_cMn_dO_{x\pm\delta}$, $La_aMn_bNi_cAl_dO_{x\pm\delta}$, $La_aMn_bAl_cO_{x\pm\delta}$, $Sc_aCu_{bl}Mn_cO_{x\pm\delta}$, $Sc_aZn_bMn_cO_{x\pm\delta}$, $La_aZr_bO_{x\pm\delta}$, $Mn_aSc_bO_{x\pm\delta}$, and $Pr_aIn_bZn_cO_{x\pm\delta}$, where a, b, c, and d are each between 0 and 1, the sum of a through d equals 1 to 3, x is the sum of a through d plus 1, and δ is the vacancy concentration or excess oxygen concentration.

6. The catalyst of system of claim 1 wherein the metal-based component is a combination of at least one of oxygen and sulfur, at least one metal selected from Groups 5-15, and at least one metal selected from Groups 1, 2, and 4 of the Periodic Table of the Elements.

7. The catalyst system of claim 6, wherein the at least one metal selected from Groups 5–15 comprises at least one of niobium, molybdenum, tungsten, manganese, iron, cobalt, iridium, nickel, palladium, platinum, copper, zinc, aluminum, gallium, indium, germanium, tin, antimony, and bismuth; the at least one metal selected from Groups 1 and 2 comprises at least one of sodium, potassium, magnesium, calcium, strontium, and barium; and the at least one metal selected from Group 4 comprises at least one of titanium and zirconium.

8. The catalyst system of claim 7, wherein the at least one metal selected from Groups 5–15 comprises at least one of manganese, iron,

cobalt, nickel, zinc, aluminum, indium, tin, antimony, and bismuth; the at least one metal selected from Groups 1 and 2 comprises at least one of sodium, potassium, magnesium, calcium, strontium, and barium; and the at least one metal selected from Group 4 comprises at least one of titanium and zirconium.

9. The catalyst system of claim 7 wherein the at least one metal-based component comprises one or more of $K_aBa_bMn_cO_{x\pm\delta}$, $K_aMg_bMn_cO_{x\pm\delta}$, $Na_aMg_bMn_cO_{x\pm\delta}$, $Mn_aMg_bO_{x\pm\delta}$, $K_aSr_bMn_cO_{x\pm\delta}$, $In_aCa_bMn_cO_{x\pm\delta}$, $Bi_aCa_bMn_cCo_dO_{x\pm\delta}$, $Bi_aCa_bMn_cNi_dO_{x\pm\delta}$, $Ca_aMn_bSn_cCo_dO_{x\pm\delta}$, $In_aMg_bMn_cAl_dO_{x\pm\delta}$, $In_aZn_bMn_cAl_dO_{x\pm\delta}$, $Na_aBa_bMn_cO_{x\pm\delta}$, $Na_aCo_bMn_cO_{x\pm\delta}$, $Ca_aMn_bSb_cO_{x\pm\delta}$, $Ca_aMn_bCo_cAl_dO_{x\pm\delta}$, $Sr_aSb_bSn_cMg_dO_{x\pm\delta}$, $K_aCo_bMn_cO_{x\pm\delta}$, $Mn_aMg_bO_{x\pm\delta}$, $Ni_aMg_bMn_cO_{x\pm\delta}$, $Mn_aMg_bAl_cO_{x\pm\delta}$, $Mn_aMg_bTi_cO_{x\pm\delta}$, $Sr_aSb_bCa_cO_{x\pm\delta}$, $Sr_aTi_bSn_cAl_dO_{x\pm\delta}$, $Sr_aMn_bTi_cAl_dO_{x\pm\delta}$, $Ca_aMn_bO_{x\pm\delta}$, $Ca_aMn_bO_{x\pm\delta}$, $Ca_aZr_bAl_cO_{x\pm\delta}$, $Bi_aCa_bMn_cO_{x\pm\delta}$, $Bi_aSr_bCo_cFe_dO_{x\pm\delta}$, $Ba_aMn_bO_{x\pm\delta}$, $Ca_aMn_bAl_cO_{x\pm\delta}$, $Ca_aNa_bSn_cO_{x\pm\delta}$, and $Ba_aZr_bO_{x\pm\delta}$, where a, b, c, and d are each between 0 and 1, the sum of a through d equals 1 to 3, x is the sum of a through d plus 1, and δ is the vacancy concentration or excess oxygen concentration.

10. The catalyst of system of claim 1 wherein the metal-based component is a combination of at least one of oxygen and sulfur, at least one metal selected from Groups 1-2, at least one metal selected from Group 3, and at least one metal selected from Groups 4-15 of the Periodic Table of the Elements.

11. The catalyst system of claim 10, wherein the at least one metal selected from Groups 1-2 comprises at least one of sodium, potassium, magnesium, calcium, strontium, and barium; the at least one metal selected from Group 3 comprises at least one of scandium, yttrium, lanthanum, cerium, samarium, ytterbium, and praseodymium; and the at

least one metal selected from Groups 4-15 comprises at least one of titanium, zirconium, niobium, molybdenum, tungsten, manganese, iron, cobalt, iridium, nickel, palladium, platinum, copper, zinc, aluminum, gallium, indium, germanium, tin, antimony, and bismuth.

12. The catalyst system of claim 11, wherein the at least one metal selected from Groups 1 and 2 comprises at least one of sodium, calcium, strontium and barium; the at least one metal selected from Group 3 comprises at least one of scandium, yttrium, and lanthanum; and the at least one metal selected from Groups 4-15 comprises at least one of titanium, manganese, iron, cobalt, nickel, copper, aluminum, gallium, and tin.

13. The catalyst system of claim 11 wherein the at least one metal-based component comprises one or more of $La_aCa_bMn_cCo_dTi_eO_{x\pm\delta}$, $La_aCa_bMn_cCo_dSn_eO_{x\pm\delta}$, $La_aCa_bCo_cO_{x\pm\delta}$, $La_aCa_bMn_cNi_dO_{x\pm\delta}$, $La_aCa_bMn_cCo_dSn_eO_{x\pm\delta}$, $La_aCa_bMn_cCo_dAl_eO_{x\pm\delta}$, $La_aCa_bMn_cCo_dO_{x\pm\delta}$, $Ba_aK_bBi_cLa_dO_{x\pm\delta}$, $La_aCa_bMn_cTi_dAl_eO_{x\pm\delta}$, $La_aCa_bCo_cNi_dAl_eO_{x\pm\delta}$, $La_aCa_bCo_cTi_dO_{x\pm\delta}$, $La_aCa_bMn_cO_{x\pm\delta}$, $Ba_aBi_bLa_cO_{x\pm\delta}$, $La_aCa_bMn_cMg_dO_{x\pm\delta}$, $La_aCa_bMn_cFe_dO_{x\pm\delta}$, $La_aSr_bCo_cAl_dO_{x\pm\delta}$, $Ba_aBi_bYb_cO_{x\pm\delta}$, $Ba_aBi_bSn_cLa_dO_{x\pm\delta}$, $La_8Ca_bMn_cGa_dO_{x\pm\delta}$, $La_aCa_bMn_cSn_dAl_eO_{x\pm\delta}$, $La_aCa_bMn_cCu_dO_{x\pm\delta}$, $La_aCa_bMn_cCo_dGa_eO_{x\pm\delta}$, $La_aCa_bMn_cAl_dO_{x\pm\delta}$, $La_aCa_bCo_cAl_dO_{x\pm\delta}$, $Ba_aBi_bSn_cLa_dO_{x\pm\delta}$, $La_aCa_bFe_cCo_dO_{x\pm\delta}$, $La_aCa_bMn_cCo_dNi_eAl_fO_{x\pm\delta}$, $Y_aCa_bMn_cO_{x\pm\delta}$, $La_aCa_bFe_cCo_dO_{x\pm\delta}$, and $Sr_aNa_bSn_cY_dO_{x\pm\delta}$, where a, b, c, d, e and f are each between 0 and 1, the sum of a through f equals 1 to 3, x is the sum of a through f plus 1, and δ is the vacancy concentration or excess oxygen concentration.

14. The catalyst of system of claim 1 wherein the metal-based component is a combination of at least one of oxygen and sulfur and at

least two metals selected from Groups 4-15 of the Periodic Table of the Elements.

15. The catalyst system of claim 14, wherein the at least two metals selected from Groups 4-15 comprise at least one of titanium, zirconium, niobium, molybdenum, tungsten, manganese, iron, cobalt, iridium, nickel, palladium, platinum, copper, zinc, aluminum, gallium, indium, germanium, tin, antimony, and bismuth.

16. The catalyst system of claim 15, wherein the at least two metals selected from Groups 4-15 comprise at least one of titanium, manganese, cobalt, copper, zinc, aluminum, and indium.

17. The catalyst system of claim 15 wherein the at least one metal-based component comprises one or more of $In_aCu_bMn_cO_{x\pm\delta}$, $Mn_aCo_bO_{x\pm\delta}$, $In_aZn_bMn_cAl_dO_{x\pm\delta}$, $In_aZn_bMn_cO_{x\pm\delta}$, $Mn_aZn_bO_{x\pm\delta}$, $Mn_aZn_bAl_cO_{x\pm\delta}$, $In_aMn_bO_{x\pm\delta}$, $In_aMn_bAl_cO_{x\pm\delta}$, and $Mn_aZn_bTi_cO_{x\pm\delta}$, where a, b, c, and d are each between 0 and 1, the sum of a through d equals 1 to 3, x is the sum of a through d plus 1, and δ is the vacancy concentration or excess oxygen concentration.

18. The catalyst system of claim 1, wherein the metal-based component comprises at least one crystal structure selected from perovskite crystal structure, spinel crystal structure, or birnessite crystal structure.

19. The catalyst system of claim 18, wherein the metal-based component comprises at least one perovskite crystal structure.

20. The catalyst system of claim 1, wherein the metal-based component further comprises at least one of at least one support, at least one filler and at least one binder.

21. The catalyst system of claim 1, wherein the solid acid component is at least one of one or more amorphous solid acids, one or more crystalline solid acids, one or more supported acids, and mixtures thereof.

22. The catalyst system of claim 1, wherein the solid acid component comprises at least one molecular sieve.

23. The catalyst system of claim 22, wherein the molecular sieve comprises at least one zeolite.

24. The catalyst system of claim 23, wherein the zeolite comprises at least one of MFI and faujasite.

25. The catalyst system of claim 24, wherein the zeolite comprises at least one of ZSM-5 and Y zeolite.

26. The catalyst system of claim 22, wherein the molecular sieve comprises at least one of crystalline silicates, crystalline substituted silicates, crystalline aluminosilicates, crystalline substituted aluminosilicates, crystalline aluminophosphates, crystalline substituted aluminophosphates, zeolite-bound-zeolite, having 8- or greater-than-8 membered oxygen rings in framework structures.

27. The catalyst system of claim 26, wherein crystalline substituted aluminophosphates comprise SAPO, MeAPO, MeAPSO, ELAPO, and ELAPSO.

28. The catalyst system of claim 1, wherein the solid acid component further comprises at least one of at least one support, at least one filler and at least one binder.

29. The catalyst system of claim 1, wherein the solid acid component is in physical admixture with the metal-based component.

30. The catalyst system of claim 1, wherein the solid acid component and the metal-based component are chemically bound.

31. The catalyst system of claim 1, wherein the weight ratio of solid acid component to the total weight of metal-based component is 1:1000 to 1000:1.

32. A process for treating a hydrocarbon feedstream comprising simultaneously contacting the feedstream under cracking conditions with a catalyst system comprising (1) at least one solid acid component and (2) at least one metal-based component, said metal-based component consisting essentially of (a) a metal combination selected from the group consisting of:

i) at least one metal from Group 3 and at least one metal from Groups 4-15 of the Periodic Table of the Elements;

ii) at least one metal from Groups 5-15 of the Periodic Table of the Elements, and at least one metal from at least one of Groups 1, 2, and 4 of the Periodic Table of the Elements;

iii) at least one metal from Groups 1-2, at least one metal from Group 3, and at least one metal from Groups 4-15 of the Periodic Table of the Elements; and

iv) two or more metals from Groups 4-15 of the Periodic Table of the Elements

and (b) at least one of oxygen and sulfur, wherein the at least one of oxygen and sulfur is chemically bound both within and between the metals.

33. The catalyst of system of claim 32 wherein the metal-based component is a combination of at least one of oxygen and sulfur, at least

one metal selected from Group 3, and at least one metal selected from Groups 4-15 of the Periodic Table of the Elements.

34. The catalyst of system of claim 32 wherein the metal-based component is a combination of at least one of oxygen and sulfur, at least one metal selected from Groups 5-15, and at least one metal selected from Groups 1, 2, and 4 of the Periodic Table of the Elements.

35. The catalyst of system of claim 32 wherein the metal-based component is a combination of at least one of oxygen and sulfur, at least one metal selected from Groups 1-2, at least one metal selected from Group 3, and at least one metal selected from Groups 4-15 of the Periodic Table of the Elements.

36. The catalyst of system of claim 32 wherein the metal-based component is a combination of at least one of oxygen and sulfur and at least two metals selected from Groups 4-15 of the Periodic Table of the Elements.

37. The process of claim 32, wherein the hydrocarbon feedstream is cracked and the resultant hydrogen simultaneously combusted.

38. The process of claim 37, wherein said hydrogen combustion comprises selective hydrogen combustion.

39. The process of claim 38, wherein the selective hydrogen combustion is anaerobic selective hydrogen combustion without the feeding of free-oxygen containing gas into the reactor.

40. The process of claim 38, wherein the selective hydrogen combustion is conducted with the feeding of free-oxygen containing gas into the reactor.

41. The process of Claim 32, wherein the catalyst system is regenerated periodically.

42. The process of claim 32, wherein the solid acid component is at least one of one or more amorphous solid acids, one or more crystalline solid acids, one or more supported acids and mixtures thereof.

43. The process of claim 32, wherein the solid acid component comprises at least one molecular sieve.

44. The process of claim 32, wherein the weight ratio of solid acid component to the total weight of metal-based component is 1:1000 to 1000:1.

45. The process of claim 32, wherein the process temperature is from about 300 to about 800°C.

46. The process of claim 32, wherein the process pressure is from 0.1 to 10 atmospheres (10 to 1000kPa).

47. The process of claim 32 wherein the catalyst system to oil ratio is from 0.01 to 1000.

48. The process of claim 32, which produces liquid and gaseous hydrocarbons.

49. The process of claim 32, wherein the solid acid component is at least one cracking catalyst and the metal-based component is at least one selective hydrogen combustion catalyst.

50. The process of claim 49, wherein the cracking catalyst is at least one of at least one fluid catalytic cracking base catalyst, at least one fluid catalytic cracking additive catalyst, and mixtures thereof.

51. The process of claim 32, wherein the added heat is reduced compared to the added heat required in a process for treating a hydrocarbon feedstream operated under the same conditions without a metal-based component in the catalyst system.

52. The process of claim 51, wherein the added heat is less than 90% of the added heat required in a process for treating a hydrocarbon feedstream operated under the same conditions without a metal-based component in the catalyst system.

53. The process of claim 32, wherein the hydrocarbon feedstream comprises at least one of gas oil, steam cracked gas oil and residues; heavy hydrocarbonaceous oils comprising materials boiling above 566°C; heavy and reduced petroleum crude oil, petroleum atmospheric distillation bottom, petroleum vacuum distillation bottom, heating oil, pitch, asphalt, bitumen, other heavy hydrocarbon residues, tar sand oils, shale oil, liquid products derived from coal liquefaction processes, steam heating oil, jet fuel, diesel, kerosene, gasoline, coker naphtha, steam cracked naphtha, catalytically cracked naphtha, hydrocrackate, reformate, raffinate reformate, Fischer-Tropsch liquids, Fischer-Tropsch gases, natural gasoline, distillate, virgin naphtha, C_{5+} olefins, C_{5+} paraffins, ethane, propane, butanes, butenes and butadiene, olefinic or paraffinic feedstreams.

54. The process of claim 53, wherein the feedstream comprises at least one of paraffins, olefins, aromatics, or naphthenes

55. A process comprising:

(A) charging at least one hydrocarbon feedstream to a fluid catalytic cracking reactor,

(B) charging a hot fluidized cracking/selective hydrogen combustion catalyst system from a catalyst regenerator to said fluid catalytic cracking reactor, said catalyst system comprising (1) at least one solid acid component and (2) at least one metal-based component, said metal-based component consisting essentially of (a) a metal combination selected from the group consisting of:

i) at least one metal from Group 3 and at least one metal from Groups 4-15 of the Periodic Table of the Elements;

ii) at least one metal from Groups 5-15 of the Periodic Table of the Elements, and at least one metal from at least one of Groups 1, 2, and 4 of the Periodic Table of the Elements;

iii) at least one metal from Groups 1-2, at least one metal from Group 3, and at least one metal from Groups 4-15 of the Periodic Table of the Elements; and

iv) two or more metals from Groups 4-15 of the Periodic Table of the Elements

and (b) at least one of oxygen and sulfur, wherein the at least one of oxygen and sulfur is chemically bound both within and between the metals;

(C) catalytically cracking said feedstream(s) and combusting resultant hydrogen at about 300 to about 800°C in the presence of said catalyst system to produce a stream of cracked products and uncracked feed and a spent catalyst system which are discharged from said reactor,

(D) separating a phase rich in said cracked products and uncracked feed from a phase rich in said spent catalyst system,

(E) stripping said spent catalyst system at stripping conditions to produce a stripped catalyst phase,

(F) decoking and oxidizing said stripped catalyst phase in a catalyst regenerator at catalyst regeneration conditions to produce said hot

fluidized cracking/selective hydrogen combustion catalyst system, which is recycled to the said reactor, and

(G) separating and recovering said cracked products and uncracked feed.

56. The process of claim 55, wherein NO_x emissions are reduced below the level of NO_x emissions resulting from regeneration of the fluidized cracking catalyst without the metal-based component.

57. The process of claim 56 wherein NO_x emissions are reduced below 50% of the level of NO_x emissions resulting from regeneration of the fluidized cracking catalyst without the metal-based component.

58. The catalyst of system of claim 55 wherein the metal-based component is a combination of at least one of oxygen and sulfur, at least one metal selected from Group 3, and at least one metal selected from Groups 4-15 of the Periodic Table of the Elements.

59. The catalyst of system of claim 55 wherein the metal-based component is a combination of at least one of oxygen and sulfur, at least one metal selected from Groups 5-15, and at least one metal selected from Groups 1, 2, and 4 of the Periodic Table of the Elements.

60. The catalyst of system of claim 55 wherein the metal-based component is a combination of at least one of oxygen and sulfur, at least one metal selected from Groups 1-2, at least one metal selected from Group 3, and at least one metal selected from Groups 4-15 of the Periodic Table of the Elements.

61. The catalyst of system of claim 55 wherein the metal-based component is a combination of at least one of oxygen and sulfur and at least two metals selected from Groups 4-15 of the Periodic Table of the Elements.

62. The process of claim 55, wherein the cracking/selective hydrogen combustion catalyst system comprises a physical mixture of at least one fluid catalytic cracking catalyst component and at least one selective hydrogen combustion catalyst component.

63. The process of claim 55, wherein the catalytic cracking catalyst component comprises at least one of a fluid catalytic cracking base catalyst component and a fluid catalytic cracking additive catalyst component.

64. The process of Claim 63, wherein the fluid catalytic cracking additive catalyst component is at least one of an octane-boosting additive, a metal passivation additive, a CO oxidation additive, a coke oxidation additive, an SOx reduction additive, a NOx reduction additive, or mixture thereof.

65. The process of Claim 55, wherein the cracking/selective hydrogen combustion catalyst system comprises at least one fluid catalytic cracking catalyst component chemically bound to at least one selective hydrogen combustion catalyst component.

66. The process of claim 65, wherein the fluid catalytic cracking catalyst component comprises at least one of a fluid catalytic cracking base catalyst component and a fluid catalytic cracking additive catalyst component.

67. The process of Claim 66, wherein the additive catalyst component is at least one of octane-boosting additives, metal passivation additives, CO oxidation additives, coke oxidation additives, SO_x reduction additives, NO_x reduction additives, and mixtures thereof.

68. A process comprising contacting at least one hydrocarbon feedstream with a cracking/selective hydrogen combustion catalyst system under effective catalytic reaction conditions to produce liquid and/or gaseous products comprising cracked hydrocarbons, wherein the yield of hydrogen is less than the yield of hydrogen when contacting said hydrocarbon feedstream(s) with said cracking catalyst alone under said catalytic reaction conditions.

69. The process of claim 68 wherein the cracking/selective hydrogen combustion catalyst system is regenerated with lower NO_x concentrations in the resulting flue gas than with regeneration of the cracking catalyst alone.